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(71) Applicant *(for all designated States except US)*: TETRONICS RESEARCH AND DEVELOPMENT COMPANY LIMITED [GB/GB]; 5b Lechlade Road, Faringdon, Oxon SN7 9AJ (GB).

(72) Inventor; and
(75) Inventor/Applicant *(for US only)* : COWX, Peter, Malcolm [GB/GB]; 3 New Cottages, Berrycroft, Ashbury, Wiltshire SN6 8LX (GB).

(74) Agent: SHAW, Laurence; George House, George Road, Edgbaston, Birmingham B15 1PG (GB).

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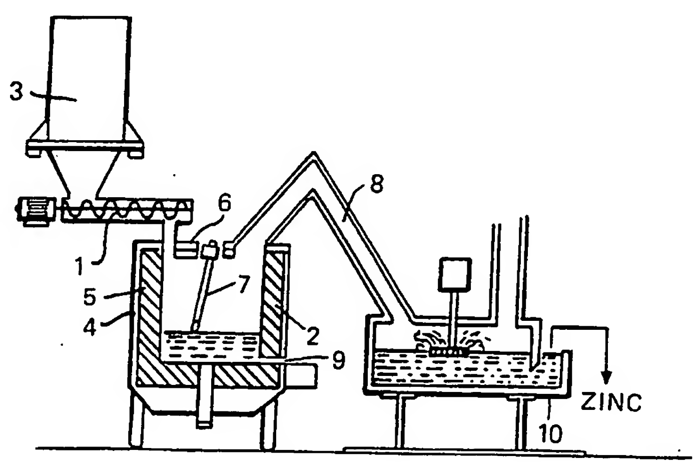

(57) Abstract

Zinc is recovered by melting in a furnace a mass containing oxides of zinc and iron, a slag-forming flux material and a carbonaceous material, the content of the carbonaceous material being selected to avoid excessive foaming. The zinc vapour produced is condensed in a condensor (10) having an impeller (20) and a cooling circuit (30).

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METAL RECOVERY

The fume generated in the Electric Arc Furnace (EAF) production of carbon steel typically contains 30 to 50% iron oxide, 15 to 35% ZnO and 5 to 40% PbO. There is economic advantage in selectively reducing and recovering at least the zinc in such a way as to leave the iron present as an oxide in a slag phase.

It is known to selectively reduce steelmaking dusts in a rotary kiln by counter-current contact between condensed material and gas phases. The relatively low temperature and correspondingly high oxygen potential of the exhaust gas stream means that the zinc can be recovered only as a low value oxide product. In the treatment of polymetallic materials, it is important to control the furnace atmosphere (redox potential), temperature and the slag chemistry very closely in order to optimise the recovery of valuable metal product. Accordingly, it is preferable that a furnace be used, in which the heat input is independent of the furnace operating atmosphere.

It is known to vaporize a mixture of the EAF dust, a reductant and a flux in a plasma arc furnace to produce metal vapours, and to condense the vapours in a condenser. The practical yield obtained is less than the theoretical value. It is an overall

object of this invention to provide a particularly efficient way of carrying out the process. The invention is based on the first appreciation that if the content of a carbonaceous reductant is controlled, foaming of the mass in the furnace leading to carry over of particulates and contamination of the metal vapour can be avoided, and on a second appreciation that the temperature of the liquid melt in the condenser should be controlled in a particular way to increase the yield and on a third appreciation that a rotor mechanism in the condenser must be constructed and located in a particular way in order to withstand rotary speeds necessary to recover metal at high yield.

According to the invention in one aspect, there is provided a method of recovering zinc from a mass containing oxides of zinc and iron, such as dust resulting from the manufacture of carbon steel in an electric arc furnace, the method comprising feeding the mass and a carbonaceous material and a slag-forming flux material to a plasma furnace, melting the mixture to form zinc vapour, passing the vapour to a condenser to recover zinc vapour, characterised in that the content of the carbonaceous material is sufficient to reduce the zinc oxide to zinc and the iron oxide (Fe_2O_3) to FeO and Fe without causing the molten mass in the furnace to be subjected to excessive foaming.

Preferably the mass to be treated comprises approximately (by weight) 20 to 30% Fe, 15 to 30% Zn, balance Pb, Ca, Cl, Fe, Na

and K.

Preferably the flux comprises sources of CaO or SiO_2 and optionally Al_2O_3.

It is a much preferred feature of the method that the content of the carbonaceous material is adjusted relative to both the mass and the flux. Preferably the content of the carbonaceous material comprises from about 3% to about 20% by weight of the mixture to be melted. More specifically, the content of carbonaceous material is about 10% in the case of a mixture comprising

30%	zinc oxide
40%	iron oxide

and the content of carbonaceous material is about 8% in the case of a mixture comprising

20%	zinc oxide
50%	iron oxide

While the carbonaceous material may be selected from a wide range of substances, preferably the carbonaceous material is selected from coal, coke, anthracite or the like having a high carbon dioxide reactivity of at least 2 as measured by the NCB blast furnace test.

According to a second aspect of the invention there is provided a condenser for use in a method of condensing zinc or like vapour, the condenser comprising a vessel having a chamber having a roof, an inlet in the roof for the supply of the metal vapour, an outlet spaced from the inlet and located in the roof for the egress of uncondensed gaseous material, a rotary impeller mounted in the roof and extending towards the floor, an outlet for egress of condensed material present adjacent the floor, a cooling circuit present in the vessel above the floor, arranged to cool the liquid zinc sufficiently to cause condensation of the zinc vapours.

In another aspect, the invention provides a method of condensing metal vapour in a vessel as just defined, the method comprising passing metal vapour into the vessel through the inlet, rotating the impeller to cause a spray of liquid zinc and the vapours to condense thereon, positioning the rotary shaft so that the lower end thereof extends a short distance into the condensed metal, passing cooling medium through the cooling circuit to cool the condensed liquid metal, and removing the liquid metal from the vessel via the outlet.

Preferably, the shaft and rotor blade assembly has an alloy outer portion and is rotated at a speed of about 300 to about 600 rpm. The alloy is preferably molybdenum tungsten or the like.

In another aspect, the invention provides a rotor assembly for the purpose specified, comprising a metal rotor shaft, a sleeve mounted on the shaft and a rotor blade assembly, the sleeve and rotor blade being formed of molybdenum tungsten alloy or the like or graphite.

In order that the invention may be well understood it will now be described by way of example only, with reference to the embodiment shown in the accompanying drawings in which:

Figure 1 is a schematic diagram of the process of recovering zinc from a zinciferous material;

Figure 2 is a vertical sectional view of the zinc condenser unit;

Figure 3 is a transverse sectional view of the condenser unit;

Figure 4 is an elevation, partly in section, showing the rotor in the condenser.

The diagram of Figure 1 shows schematically the apparatus used in recovering zinc metal from electric arc furnace dust formed in the melting of carbon steel. A proportioned mixture of the dust, a carbonaceous material, typically coal, and a slag fluxing

material e.g. calcium oxide, are all fed by a screw 1 to an open bath furnace 2 from a common hopper 3. The furnace comprises a vessel having a mild steel shell 4 and refractory lining 5 formed of carbon impregnated magnesia or magnesia-chrome bricks. The furnace has a roof section 6 which is watercooled and lined with a cast lining of high grade alumina. A plasma torch 7 or graphite electrode extends inwardly from the roof of the furnace. The gas stabilised plasma arc formed is transferred from the water cooled plasma torch or graphite electrode to the furnace melt which is in electrical contact with a return mild or stainless steel billet built into the furnace hearth or a suitable conductive hearth refractory. The vapours arising from the melting of the metal are fed out via a conduit 8 and the slag and any pig iron formed are intermittently tapped via a bottom outlet 9.

The conduit 8 leads to a zinc condenser 10 which is shown more fully in Figures 2 to 4.

The zinc condenser comprises a steel vessel having a refractory brick lining. The roof contains an inlet 11 for the metal vapours recovered from the furnace 1 and an outlet 12 which leads to a baghouse filter unit, not shown. An outlet 13 for the condensed zinc metal is present in a lower corner of the vessel remote from the inlet 11. A lintel 14 is present about a dished floor portion 15 to define a weir for the metal, to restrict the

entrapment of contaminants. An impeller 20 extends downwardly from the roof of the condenser and is rotated by a motor, not shown. The rotor comprises a steel shaft 21 on which is fitted a rotor sleeve 22 having a suitably shaped rotor blade assembly 23. The sleeve 23 is made of a molybdenum tungsten alloy or graphite or like refractory tough material. A cooling circuit 30 is present in the lower part of the condenser and as shown in Figures 2 and 3, comprises a pipe 31 containing pumped cooling medium, e.g. water, leading into the vessel including a generally centrally located U-loop 32. As shown, the loop 32 is reversely bent and includes an upper portion 32A and a lower portion 32B; the loop is located immediately below the rotor blade assembly 23. The walls of the condenser include windows, not shown, which in use are blocked with refractory bricks which can be knocked out for access to the interior of the condenser for ease of cleaning, when required.

In use, the preblended mixture of dust, about 5% to about 20% coke and flux is fed through feed ports in the roof into the furnace 1. The materials are heated as they descend through the furnace atmosphere and are then rapidly dissolved into a melt. The power input is controlled to maintain an operating melt temperature of between 1200 and 1600°C, preferably about 1500°C. Zinc and lead oxides are carbothermically reduced and volatilised as metal vapours and pass from the furnace into the condenser 10, leaving slag and pig iron which are tapped off as required. The

impeller 21 is rotated in a bath of molten zinc in the condenser 10 to generate a spray of metal droplets of large surface area to enable efficient condensing of the zinc vapour. The droplets accumulate in the lower part of the vessel 10. The height of the rotor is adjusted so that the lower half of the rotor blade assembly 23 is permanently in the liquid. The speed of rotation is adjusted to between about 300 to about 600 rpm to control the rate of condensation and zinc droplet size; because of the nature of the material of the rotor sleeve, it is able to withstand the rotary forces i.e. torque generated. The temperature of the liquid metal is controlled by the extraction of heat via the cooling coil 30, the shape of which and the location relative to the rotor assembly is selected, for optimum effect. The temperature of the liquid material is kept at about 525°C. The gases from the outlet 12 of the condenser 10 are burned in a combustion chamber with an excess of air being employed to cool the gas stream entering the baghouse.

The proportion of the coke added to the dust to be treated is selected so that sufficient CO is generated to reduce the zinc oxide in the dust to zinc metal and the iron oxide from Fe_2O_3 to FeO and Fe without the generation of excessive foam in the melt because if such foaming takes place, non-zinc materials, e.g. slag, will be carried over into the condenser reducing the purity of the zinc to be recovered and the operating life of the water-cooled plasma torch may be reduced. A controlled amount of slag

foaming is desirable to reduce carry-over of feed materials, to reduce the fuming of unwanted volatile species (Mg, SiO, 'FeO') formed in the plasma arc hot spot and to improve the thermal efficiency of the process by shielding the furnace refractories from the plasma arc. The flux additions to the furnace are proportioned to produce a low melting point, high fluidity slag with a basicity ratio CaO: SiO_2 of about 1.4 to about 0.8:1.

As a result of the control of the content of the carbonaceous material, plus the efficiency of recovery of the zinc metal by the rotation of the rotor at the selected speed and the control of the temperature of the liquid zinc, the overall efficiency approaches the theoretical value.

CLAIMS

1. A method of recovering zinc from a mass containing oxides of zinc and iron, the method comprising feeding the mass and a carbonaceous material and a slag-forming flux material to a plasma furnace, melting the mixture to form zinc vapour, and passing the zinc vapour to a condenser to recover zinc, characterised in that the content of the carbonaceous material is sufficient to reduce the zinc oxide to zinc and the iron oxide Fe_2O_3 to FeO without causing the molten mass in the furnace to be subjected to excessive foaming.

2. A method according to Claim 1 characterised in that the carbonaceous material comprises from about 3% to about 20% by weight of the mixture to be melted.

3. A method according to Claim 1 or 2 characterised in that the mixture to be melted contains about 30% by weight of zinc oxide and about 40% by weight of iron oxide and the content of carbonaceous material is about 10% by weight.

4. A method according to Claim 1 or 2 characterised in that the mixture contains about 20% by weight of zinc oxide and about 50% by weight of iron oxide and the content of carbonaceous

material is about 8% by weight.

5. A method according to any preceding Claim characterised in that the carbonaceous material is selected from coal, coke anthracite or a material having a carbon dioxide reactivity of at least 2 measured by the NCB blast furnace test.

6. A method according to any preceding Claim characterised in that the mass to be treated includes lead, calcium, sodium and potassium.

7. A method according to any preceding Claim characterised in that the flux is selected to produce a low melting point high fluidity slag with a basicity ratio $CaO:SiO_2$ of about 1.4 to about 0.8:1.

8. A method according to Claim 7 characterised in that the slag-forming flux material comprises sources of CaO, SiO_2 and optionally Al_2O_3.

9. A condensor for use in condensing zinc or like vapour characterised in that the condensor (10) comprises a vessel having a chamber having a roof, an inlet (11) in the roof for the supply of metal vapour, an outlet (12) for the egress of uncondensed gaseous material, a rotary impeller (20) mounted in the roof and extending to the floor (15), an

outlet (13) for egress of condensed material present adjacent the floor (15), a cooling circuit (30) present in the vessel (10) above the floor (15) and arranged to cool the liquid zinc sufficiently to cause condensation of the zinc vapour.

10. A condenser according to Claim 9 characterised in that the impeller (20) includes a metal rotor shaft (21), a sleeve (22) mounted on the shaft (21), and a rotor blade assembly (23).

11. A condenser according to Claim 9 or 10 characterised in that the shaft (21) and the blade assembly (23) are made of molybdenum tungsten or like alloy or graphite.

12. A method of condensing zinc vapour recovered from a molten mass containing oxides of zinc and iron characterised by passing metal vapour into a condensor according to any of Claims 9 to 11 through the inlet, rotating the impeller to cause a spray of zinc and the vapours to condense thereon, positioning the rotary shaft so that the lower end thereof extends a short distance into the condensed metal, passing cooling medium through the cooling circuit to cool the condensed liquid metal, and removing the liquid metal from the vessel via the outlet.

13. A method according to Claim 12 <u>characterised in that</u> the shaft is rotated at a speed of about 300 to about 600 rpm.

14. A method according to Claim 12 or 13 <u>characterised in that</u> the cooling medium is passed through the cooling circuit to keep the temperature of the liquid metal at about 525°C.

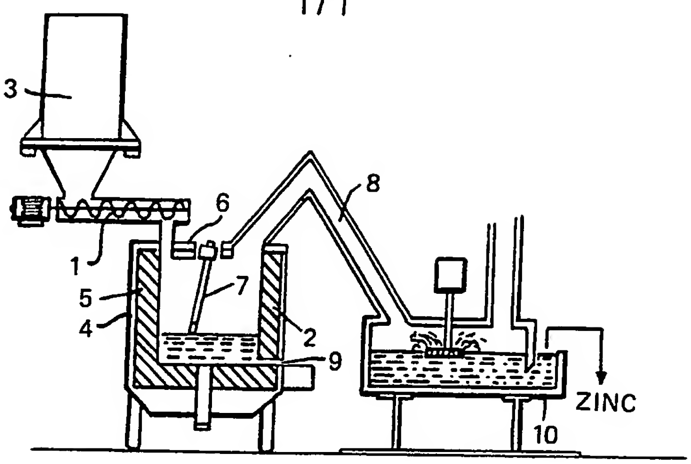


FIG. 1

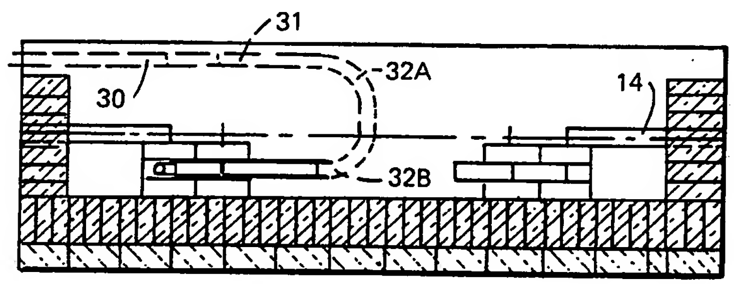
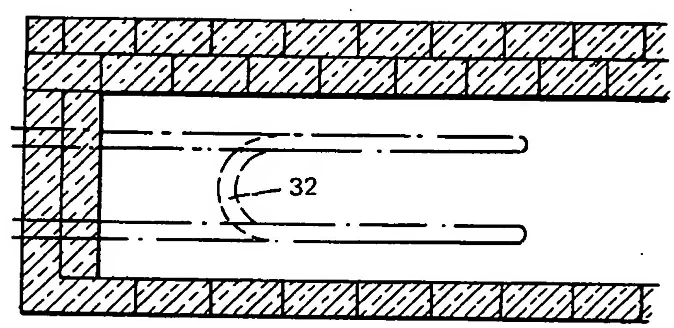


FIG. 2

FIG. 3



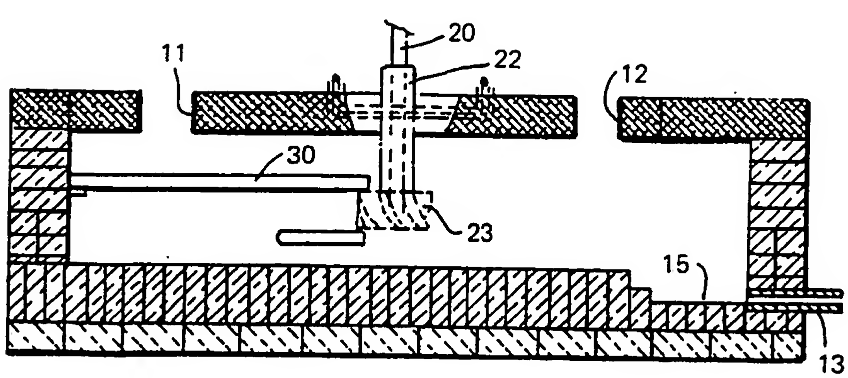


FIG. 4